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Construction of the Z/Beamlet: A New, High-Energy, Solid-State Laser System at Sandia National Laboratories

Under the auspices of the Department of Energy's Inertial Confinement Fusion (ICF) Program at Sandia National Laboratories (SNL), we are building a laser backlighter system (the Z/Beamlet) at Sandia's Z facility in Albuquerque, New Mexico. The Z facility employs electrical pulsed power to drive a z-pinch implosion, which efficiently generates x-rays to drive ICF target physics experiments. In recent years, Z has produced up to 2 MJ of x-rays per shot at 15 to 20% conversion efficiency from electrical input energy. Peak x-ray output power from Z reached over 250 TW in 1998.

The new laser backlighter system will provide a powerful new x-ray radiographic diagnostic for quantitative measurements in z-pinch-driven target experiments. In this application, new information would be obtained by recording images and/or spectra of x-ray radiation transmitted through target materials as they evolve during Z-accelerator-driven experiments or shots.

The Z-Backlighter Project involves a team of scientists, engineers, and technicians from both Lawrence Livermore National Laboratory (LLNL) and SNL, and is scheduled for completion by the end of December 2000, with shots to the Z-facility target chamber. Many of the components of the new laser system (Z/Beamlet) came from the National Ignition Facility (NIF) prototype Beamlet laser, which was built and operated at LLNL starting in 1993 and shut down after successfully demonstrating its design goals in 1998.

Numerous modifications and upgrades to LLNL's Beamlet have been made to meet Sandia's requirements for Z/Beamlet laser, and to take advantage of advances achieved in the development of NIF technology. These include construction of a new fiber-optic seed pulse generator (SPG) for the master oscillator room, with a picket fence pulse generator for pulse shaping. The pulse train shown in Figure 1 below was measured at the output of the Z/Beamlet regenerative amplifier earlier this year. When complete, the Z/Beamlet will produce up to 2 kJ of 0.53-μm laser energy in a picket fence of ≤2-ns total duration, with a final focus spot size ≤50 μm in diameter.

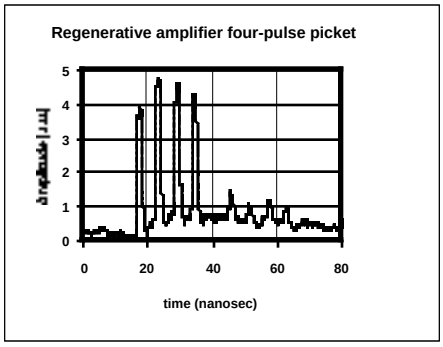

Figure 1. Picket fence laser pulse train generated by the new Z/Beamlet SPG and measured at the regenerative amplifier output. (Ralph Page)

Other major changes and modifications include: (1) upgrading the plasma electrode Pockels cell with NIF-style segmented anode and current return path; (2) changing the Beamlet amplifiers from 2x2 to a 1x2 aperture configuration, with commensurate savings in pulsed power requirements; (3) rebuilding the main cavity amplifiers with NIF-style blast-shield epoxy and side-loading the flashlamp cassettes; (4) reducing the main amplifier cavity length from 36 m to 30 m to fit in the available building space; (5) increasing the regenerative amplifier ring length to 28 ns for production of picket fence pulses up to 20 ns in overall duration. Several new optical systems have also been designed and constructed: (1) a new 1ω and 2ω output sensors and alignment systems; (2) a new 2ω relay telescope for the 75-m propagation from the frequency converter to the Z target chamber; (3) a new final focus optical system; (4) a new backlighter target alignment system; (5) a new calibration target chamber; (6) all control system computers have been replaced with Windows NT machines, and software has been updated as needed; and (7) the means have been provided for synchronizing Z/Beamlet shots with those of the Z facility within ±250 ps.

In 1999, Sandia upgraded the 10,000-ft^2 Building 986 (adjacent to the Z facility) to Class 100,000 clean-room status with ±1°F temperature control to house the Z/Beamlet laser system. Installation of laser system components began in October 1999. A recent photograph of the Z/Beamlet high bay (Figure 2 below) shows the reassembled front end of the laser as well as part of the new cavity spatial filter. Main amplifier gain tests are expected to begin in June 2000; the frequency converter system will be activated this summer; and shots to a calibration chamber will be fired before the end of fiscal year 2000. Construction of the Z/Beamlet laser at Sandia represents an important interlaboratory collaboration that allows new applications of LLNL's high-energy solid-state laser technology.

Figure 2. Z/Beamlet front end and cavity spatial filter components installed in Sandia's Building 986. (John Caird)

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